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February 15, 2002

BOX PCT

Commissioner for Patents
Washington, D.C. 20231

PCT/IB00/00985
-filed July 19, 2000

Re: Application of Wolfgang SCHUH
AUTOMATED OPTICAL INSPECTION SYSTEM WITH IMPROVED FIELD
OF VIEW
Assignee: **Orbotech Ltd. - Schuh GmbH & Co. KG**
Our Ref: Q68488

Dear Sir:

The following documents and fees are submitted herewith in connection with the above application for the purpose of entering the National stage under 35 U.S.C. § 371 and in accordance with Chapter II of the Patent Cooperation Treaty:

- ☒ an executed Declaration and Power of Attorney.
- ☐ an English translation of the International Application.
- ☐ 2 sheet(s) of drawings.
- ☐ an English translation of Article 19 claim amendments.
- ☐ an English translation of Article 34 amendments (annexes to the IPER).
- ☒ an executed Assignment and PTO 1595 form.
- ☒ a Form PTO-1449 listing the ISR references
- ☒ a Preliminary Amendment

It is assumed that copies of the International Application, the International Search Report, the International Preliminary Examination Report, and any Articles 19 and 34 amendments as required by § 371(c) will be supplied directly by the International Bureau, but if further copies are needed, the undersigned can easily provide them upon request.

The Government filing fee is calculated as follows:

Total claims	<u>6</u>	-	20	=		x	\$18.00	=	\$0.00
Independent claims	<u>1</u>	-	3	=		x	\$84.00	=	\$0.00
Base Fee									\$890.00

TOTAL FILING FEE
Recordation of Assignment
TOTAL FEE

<u>\$890.00</u>
<u>\$ 40.00</u>
<u>\$930.00</u>

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Checks for the statutory filing fee of \$890.00 and Assignment recordation fee of \$40.00 are attached. You are also directed and authorized to charge or credit any difference or overpayment to Deposit Account No. 19-4880. The Commissioner is hereby authorized to charge any fees under 37 C.F.R. §§ 1.16, 1.17 and 1.492 which may be required during the entire pendency of the application to Deposit Account No. 19-4880. A duplicate copy of this transmittal letter is attached.

Priority is claimed from:

CountryApplication NoFiling Date

Israel

131837

September 9, 1999

Respectfully submitted,

William H. Mandir

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Date: February 15, 2002

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PATENT APPLICATION
IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of

PCT/IB00/985

Wolfgang SCHUH

Appl. No.: unknown

Confirmation No.: unknown

Group Art Unit: unknown

Filed: February 15, 2002

Examiner: unknown

For: AUTOMATED OPTICAL INSPECTION SYSTEM WITH IMPROVED FIELD OF
VIEW

PRELIMINARY AMENDMENT

Commissioner for Patents
Washington, D.C. 20231

Sir:

Prior to calculation of the filing fee and examination, please amend the above-identified
application as follows:

IN THE CLAIMS:

Please enter the following amended claims:

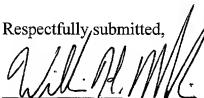
3. (Amended) The system (10) according to claim 1 wherein the fields of view (22) of
said cameras (12, 14, 16, 18) each have a width/height ratio of about 4/3.
4. (Amended) The system (10) according to claim 1 and further comprising a fifth
camera (19) positioned generally atop said generally rectangular area (15).

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REMARKS

In the Amendment, Applicant has amended claims 3 and 4 to eliminate multiple dependency. Entry and consideration of this Amendment is respectfully requested.

Respectfully submitted,



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Date: February 15, 2002

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APPENDIX

VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE CLAIMS:

The claims are amended as follows:

3. (Amended) The system (10) according to claim 1 [or claim 2] wherein the fields of view (22) of said cameras (12, 14, 16, 18) each have a width/height ratio of about 4/3.
4. (Amended) The system (10) according to [any of claims 1-3] claim 1 and further comprising a fifth camera (19) positioned generally atop said generally rectangular area (15).

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AUTOMATED OPTICAL INSPECTION SYSTEM WITH IMPROVED FIELD OF VIEW

FIELD OF THE INVENTION

The present invention relates generally to automated optical inspection systems and particularly to an automated optical inspection system with an improved and efficient field of view.

BACKGROUND OF THE INVENTION

Automated optical inspection (AOI) systems are typically used to inspect such items as printed circuit boards onto which components are mounted ("loaded PCB's") and the like. As seen in Fig. 1, prior art AOI systems for inspecting loaded PCB's typically employ four (4) CCD cameras 1, 2, 3 and 4, arranged north, east, south and west at an angle above an area to be inspected. Optionally, a fifth CCD camera may be provided positioned atop the area to be inspected. The field of view for commonly used CCD cameras is substantially rectangular, typically having a width/height (i.e., horizontal/vertical) ratio of 4/3.

In current AOI systems, the CCD sensors view a horizontal region and each camera has the same field of view. It is seen in Fig. 1 that the fields of view of cameras 1 and 3 extend to dashed lines 5 and the fields of view of cameras 2 and 4 extend to dashed lines 6. However, the actual working field of view 7 is only the area in the middle where the fields of view from both sets of opposing cameras overlap. Thus some portions of the fields of view of the cameras are not utilized, making the system somewhat inefficient.

SUMMARY OF THE INVENTION

The present invention seeks to provide an automated optical inspection system with an improved and efficient field of view.

There is thus provided in accordance with a preferred embodiment of the present invention an automated optical inspection system including four CCD cameras spaced from each other and arranged generally north, east, south and west at an angle above a generally rectangular area upon which an item to be inspected may be placed, wherein a width of the area is larger than a height of the area, each of the cameras having an optical axis and a field of view, the fields of view of the cameras being generally rectangular, wherein a width of the field of view is larger than a height of the field of view, characterized in that a pair of the cameras are positioned generally opposite each other, each having the width and height of their fields of view generally in the same direction as the width and height of the area, respectively, and the other pair of the cameras are positioned generally opposite each other and generally

perpendicular to the first-mentioned pair of cameras, each having the width and height of their fields of view generally in the same direction as the height and width of the area, respectively.

In accordance with a preferred embodiment of the present invention the fields of view of both pairs of the cameras overlap generally at a common area.

Further in accordance with a preferred embodiment of the present invention the fields of view of the cameras each have a width/height ratio of about 4/3.

Still further in accordance with a preferred embodiment of the present invention a fifth camera is positioned generally atop the generally rectangular area. Preferably the field of view of the fifth camera overlaps the fields of view of the other cameras generally at a common area.

Additionally in accordance with a preferred embodiment of the present invention the fifth camera comprises an array of cameras, and the combined field of view of the array generally corresponds to the generally rectangular area.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood and appreciated more fully from the following detailed description, taken in conjunction with the drawings in which:

Fig. 1 is a simplified pictorial illustration of a prior art automated optical inspection system; and

Fig. 2 is a simplified pictorial illustration of an automated optical inspection system constructed and operative in accordance with a preferred embodiment of the present invention.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Reference is now made to Fig. 2 which illustrates an automated optical inspection system 10 constructed and operative in accordance with a preferred embodiment of the present invention.

Automated optical inspection system 10 preferably includes four CCD cameras 12, 14, 16 and 18, spaced from each other and arranged generally north, east, south and west at an angle above an area 15 upon which an item to be inspected may be placed. (It is appreciated, of course, that the terms "north, east, south and west" are relative and are not necessarily connected to the directions of a true compass.) Optionally, a fifth CCD camera 19 may be placed atop the area to be inspected. The fifth camera 19 may comprise an array of cameras 19A, 19B, 19C and 19D, for example. The area 15 is generally rectangular, i.e., a

width W of area 15 is larger than a height H of area 15, such as a width/height ratio of about 4/3.

Each camera has an optical axis 20 and a field of view 22. The fields of view are generally rectangular, i.e., a width of the field of view is larger than a height of the field of view, such as a width/height ratio of about 4/3. It is appreciated that because of the angled arrangement of the cameras, the field of view may be slightly trapezoidal.

It is a particular feature of the present invention that the fields of view of two of the cameras positioned generally opposite each other, for example, cameras 14 and 18, are each rotated generally 90° about their optical axis. In other words, cameras 12 and 16 each have the width and height of their fields of view generally in the same direction as the width and height of area 15, respectively, and cameras 14 and 18 each have the width and height of their fields of view generally in the same direction as the *height* and *width* of area 15, respectively.

In such an arrangement, the fields of view of the cameras overlap generally at a common area, preferably a substantially rectangular working field of view. The field of view of optional top camera 19 (or cameras 19A, 19B, 19C and 19D) also preferably generally overlaps this common working field of view. This increases the working field of view and ultimately improves system speed, even though the same cameras of the prior art are employed. This also obviates the need for relatively expensive square field-of-view cameras.

As is well known in the art, rectangular field-of-view cameras may have associated with them a keystone problem, wherein the rectangular field of view becomes distorted trapezoidally. The keystone problem can be reduced or eliminated with appropriate adjustment of optics configuration and/or with algorithms, for example, relying on the so-called "Scheimpflug Principle", or other methods used in the art.

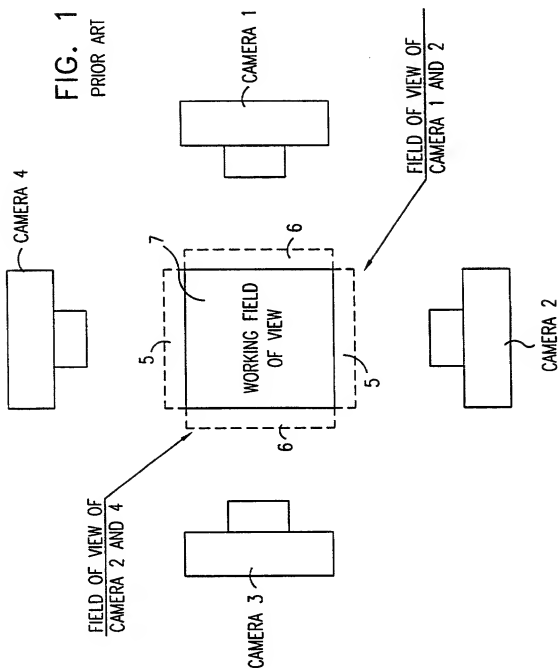
It will be appreciated by persons skilled in the art that the present invention is not limited by what has been particularly shown and described hereinabove. Rather the scope of the present invention includes both combinations and subcombinations of the features described hereinabove as well as modifications and variations thereof which would occur to a person of skill in the art upon reading the foregoing description and which are not in the prior art.

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C L A I M S

What is claimed is:

1. An automated optical inspection system (10) comprising:
four CCD cameras (12, 14, 16, 18) spaced from each other and arranged generally north, east, south and west at an angle above a generally rectangular area (15) upon which an item to be inspected may be placed, wherein a width of the area (15) is larger than a height of the area (15), each of said cameras (12, 14, 16, 18) having an optical axis (20) and a field of view (22), the fields of view (22) of said cameras (12, 14, 16, 18) being generally rectangular, wherein a width of the field of view (22) is larger than a height of the field of view (22);
characterized in that a pair of said cameras (12, 16) are positioned generally opposite each other, each having the width and height of their fields of view (22) generally in the same direction as the width and height of the area (15), respectively, and the other pair of said cameras (14, 18) are positioned generally opposite each other and generally perpendicular to the first-mentioned pair of cameras (12, 16), each having the width and height of their fields of view (22) generally in the same direction as the height and width of the area (15), respectively.
2. The system (10) according to claim 1 wherein the fields of view (22) of both pairs of said cameras (12, 14, 16, 18) overlap generally at a common area (15).
3. The system (10) according to claim 1 or claim 2 wherein the fields of view (22) of said cameras (12, 14, 16, 18) each have a width/height ratio of about 4/3.
4. The system (10) according to any of claims 1-3 and further comprising a fifth camera (19) positioned generally atop said generally rectangular area (15).
5. The system (10) according to claim 4 wherein the field of view (22) of said fifth camera (19) overlaps the fields of view of the other cameras (12, 14, 16, 18) generally at a common area (15).
6. The system (10) according to claim 4 wherein said fifth camera (19) comprises an array of cameras (19A, 19B, 19C, 19D), and wherein the combined field of view (22) of the array generally corresponds to said generally rectangular area (15).

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FIG. 1
PRIOR ART

2/2

